Scenarios and Probabilities (Continuing the Previous Session)

Yes to the latter, usually no to the former.

by
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Several Prescient Case Histories

(I don’t want to spoil the story by providing the slides in advance.)

Scenarios and Scenario Exercises Are Most Often an Undisciplined Waste of Time and Resources

Probability and the science of uncertainty are a far better bet

Prerequisite No. 10

PROBLEM

10. Uncertainty

SOLUTION

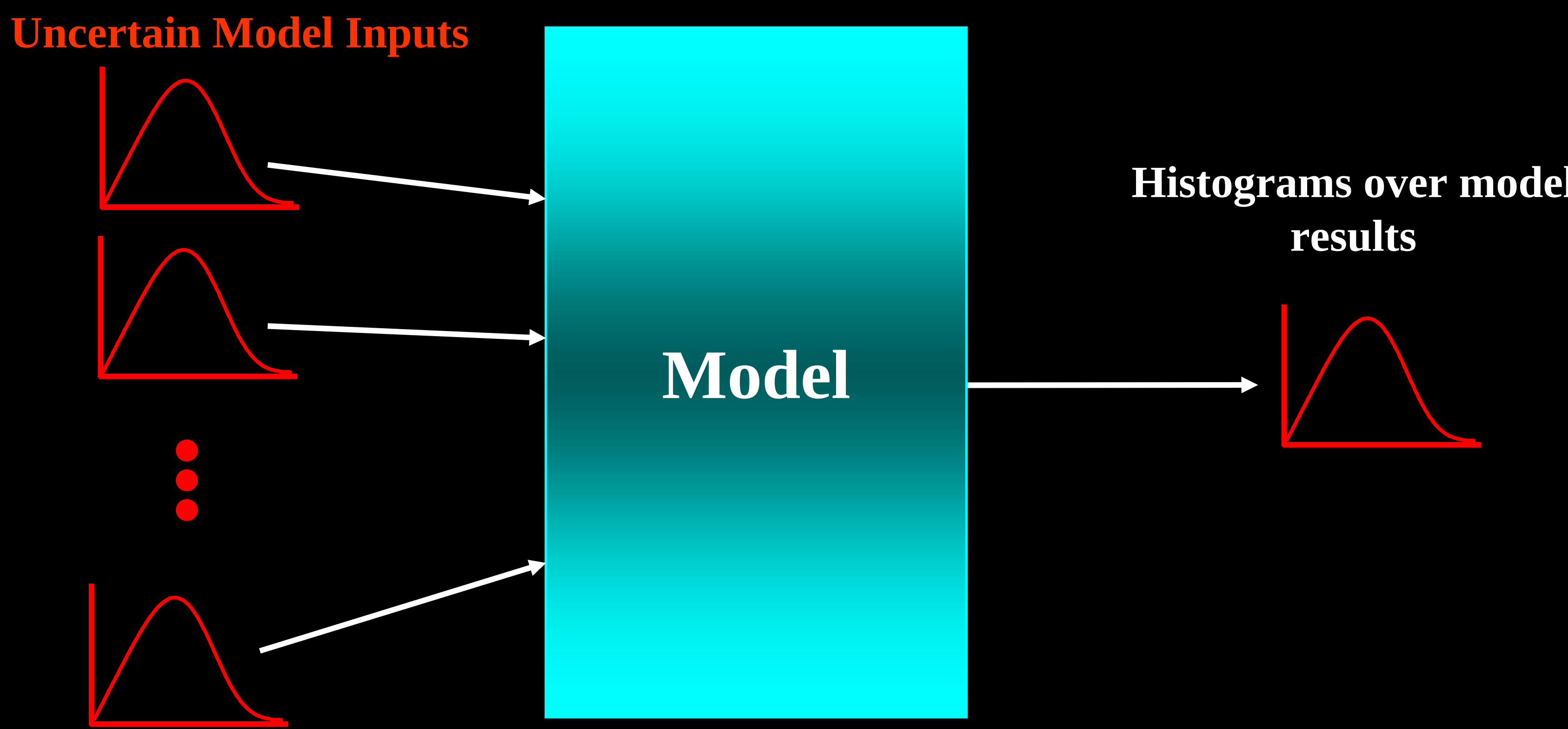
10. Sampling
    - ✓ Monte Carlo
    - ✓ Latin Hypercube
    - ✓ Stratified
    - ✓ Importance sampling

- Discrete trees or influence diagrams blow up
- Scenarios absolutely don’t cut it

"Hey, we'll just stick in some Monte Carlo samples and go!!"

Myriad "What If?" cases or samples from distributions

<u>This is error prone</u>



The Model Is a Nonlinear Relationship from the Data to a Result

$$r = M(\alpha)$$

Result — Model — Data

- α=data (usually a gigantic vector)
- r=results (usually a vector)
- M(.)=complex system of nonlinear equations
- Uncertainty in the result derives from uncertainty in the data.
- Your model is a gigantic "change of variables" problem.
  - ✓ Who here got A's in probability in college?

It is Uncertainty in the Data that Induces Uncertainty in the Result

$$r = M(\alpha)$$

- $\{\alpha\}$=multivariate, correlated, joint probability density function over the data
- Example=probability density function over resources in Palo Verde, load in Seattle, precipitation in the Cascades, <u>and</u> transmission from Colorado to Arizona
- The model induces a probability density function over the result {r}

$$M(\{\alpha\}) \rightarrow \{r\}$$

The Model Is a Nonlinear Relationship from the Data to a Result

- People want to put the expected value of the data <a> into the model and "hope" that they get the expected value of the result <r>.
- This is NOT right.

$$< \mathbf{r} > \neq \mathbf{M}(< \alpha >)$$

- There are no shortcuts in probability
  - ✓ How many of you got A's in your graduate probability courses?
  - ✓ How many of you were able to find shortcuts?

Second Order Taylor Expansion of the Model About the Mean

$$\mathbf{r} = \mathbf{M}(<\alpha>) + (\alpha - <\alpha>)^{\mathrm{T}} \nabla \mathbf{M}(<\alpha>)$$

$$+ \frac{1}{2}(\alpha - <\alpha>)^{\mathrm{T}} \nabla^2 \mathbf{M}(<\alpha>)(\alpha - <\alpha>) + \mathbf{O}\left[\left\|(\alpha - <\alpha>)^3\right\|\right]$$

- **If we integrate over α, we obtain the following expression for the expected value of the model result.**

$$<\mathbf{r}> = \mathbf{M}(<\alpha>) + 0 + \frac{1}{2}\int d\alpha(\alpha - <\alpha>)^{\mathrm{T}} \nabla^2 \mathbf{M}(<\alpha>)(\alpha - <\alpha>)$$

$$+ \mathbf{O}\left[\left\|(\alpha - <\alpha>)^3\right\|\right]$$

The first order effect of uncertainty in your model

The Uncertainty Term Combines the Variance/Covariance Over Sample Uncertainties and the Nonlinearity of the Model

Curvature (Second derivative matrix that quantifies nonlinearity) of the model

Model nonlinearity really matters

$$\frac{1}{2}\int \mathbf{d}\alpha(\alpha-<\alpha>)^{T}\nabla^{2}\mathbf{M}(<\alpha>)(\alpha-<\alpha>)$$

Variance/covariance matrix of the uncertain input variables

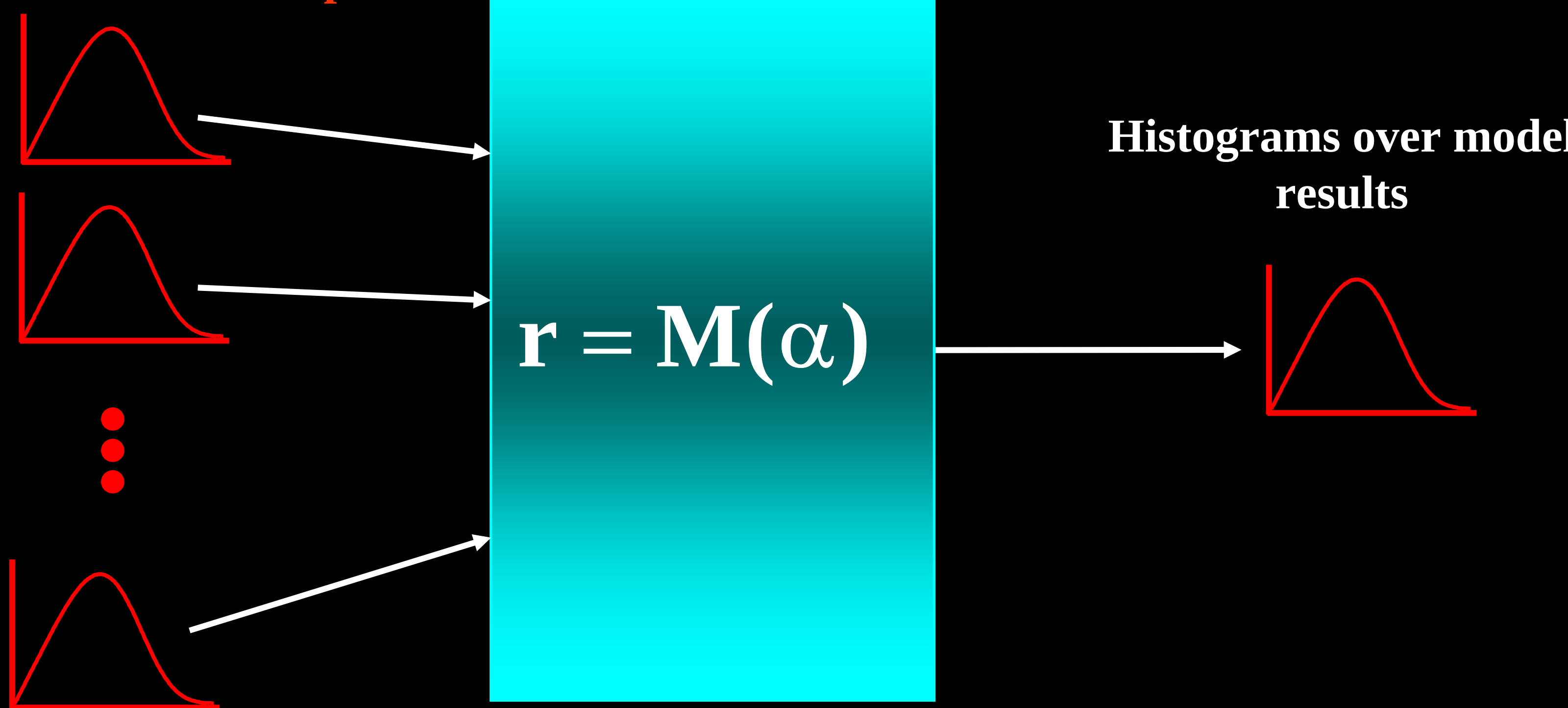
Probabilistic dependence really matters

The Two Most Important Elements of Modeling Uncertainty

You must have a **JOINT, CORRELATED probability density** over all model inputs

You must have a fully accurate, **NONLINEAR** model

Uncertain Model Inputs



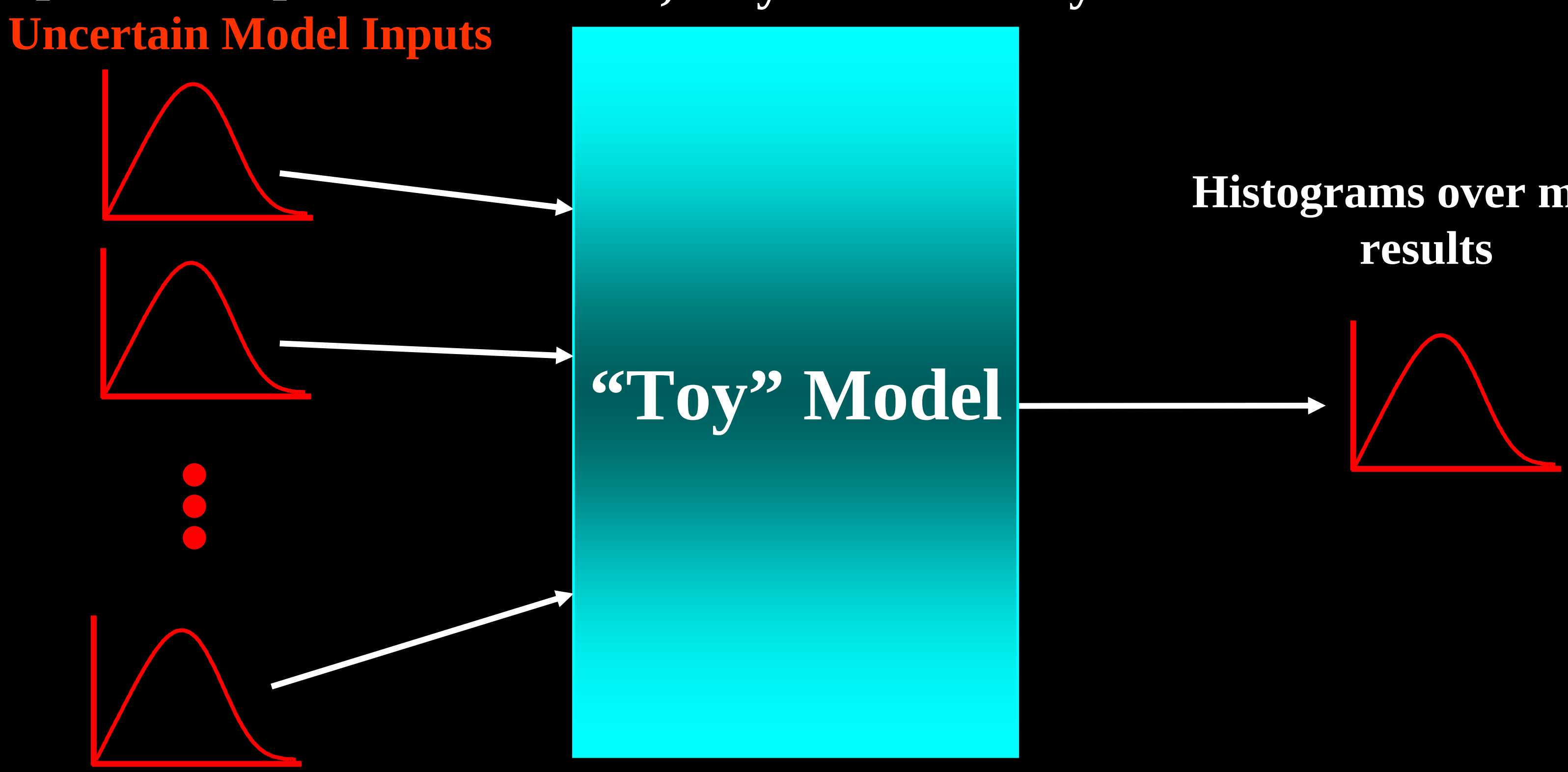
Two of the Three Biggest Mistakes People Make

- **Too much probabilistic independence among inputs**
  - ✓ **Examples**
    - **Independent samples of individual plant outage**
    - **Independent samples of price volatility (random walk)**
    - **Independent samples of gas supply and cost across basins**
- **Linear or linear programming models. With such models, you are wasting your time incorporating uncertainty—just calculate the mean value and move on. If the model is linear, key probabilistic terms are generall additive, and therefore you are wasting your time simulating. You can do the math directly.**

You Cannot Run At Risk! Or Crystal Ball…They Aren't Robust Enough

It is too easy to have independent inputs

You cant use a full size model, only an Excel "toy"



And Yet This Isn't the Worst Part!

This is what distinguishes physical models from economic/agent based models.

Prerequisite No. 11

PROBLEM

11. **The real world is "agent based," a myriad of independent agents all seeking maximum profits or minimum costs.**

SOLUTION

11. **Goal seeking fundamental microeconomic approach (impossible with LP, NLP, dispatch, production simulation, system dynamics)**
    - ✓ **They give Ph. D.'s in economics and game theory**
    - ✓ **There is no dictator that coordinates decisions or sets prices (and never will be!)**
    - ✓ **There is no creativity allowed on this point**

Prerequisite No. 12

PROBLEM

12. **Agents have expectations, and they act on them**

SOLUTION

12. **Three alternatives**
    - ✓ **Rational expectations**
    - ✓ **Perfect expectations/lagged decision making (information diffusion)**
    - ✓ **Imperfect expectations/perfect decision making (Arrow Debreu)**

- **We have the first two, and the third is on the way**

Agents Have DIFFERENT Probabilities Over the Same Event

- **Monte Carlo models have a <u>single probability distribution that is common and identical across every agent in their model</u>.**
- **This is <u>wrong</u> on its face**
  - ✓ **There are dramatic asymmetries of information in the real world (e.g., patents, basinal knowledge, IP, conservatism, access to data, classification, intentional deception, propaganda, individual plant knowledge, scope and scale of business, experience)**
  - ✓ **In general, every agent has different information about everything**
  - ✓ **There is no "Monte Carlo" distribution to sample from; every agent has his or her own distribution!!!**

Why Is the Agent View Important?

- COMPANIES build power plants, drill wells, build LNG regasification, etc.; governments do not.
- Companies pursue profits, not greater social goals such as WECC-wide cost minimization or congestion alleviation.
- Every company has its own private perception, probability, and information set.
- Once facilities are in place, each and every asset throughout the WECC is affected.
- The agent view is fundamental to success.

Do Not Hire Your Kids to Paint the House!

- **Do not allow dilettantes or opportunists to do probability work.**
- **Incorporating probability with economics is really hard.**
- **Altos has been doing it for some 30 years.**
- **Altos is incorporating full agent based probabilistic treatment into MarketBuilder.**

